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AN AUTOMATIC DATA ACQUISITION SYSTEM FOR THE 150-METER GROUND WINDS TOWER FACILITY, KENNEDY SPACE CENTER

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16. ABSTRACT

This report summarizes the design concepts and operational functions of an automatic meteorological data acquisition system for use with the NASA 150-meter ground winds tower at Kennedy Space Center. The technical approach and system specifications are presented in a generalized manner to give a clear overall view of the automatic system and to suggest methods and guidelines for using similar digital systems in other applications. Samples of the output meteorological data are illustrated together with brief discussions of their applications. References are given for additional details on the 150-meter tower structure as well as the engineering development and computer software programs associated with the automatic system.

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FOREWORD

The Automatic Data Acquisition System described in this report was developed by Southwest Research Institute in response to NASA-Marshall Space Flight Center requirements for updating and automating the 150-meter ground winds tower facility located at Kennedy Space Center, Florida.

Additional information pertaining to the Automatic Data Acquisition System is Available from Southwest Research Institute, San Antonio, Texas (Mr. W. B. Tarver, Jr., Department of Electronic Systems Research, telephone 512-684-5111) Inquiries concerning the NASA 150-meter ground winds tower facility should be directed to NASA-Marshall Space Flight Center, Huntsville, Alabama (Mr. Dennis Camp, Aero-Astrodynamics Laboratory, MSFC, telephone 205-453-3157).

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INTRODUCTION – THE PROBLEM

In the design and operational use of aerospace vehicles, significant attention must be given to the effects of atmospheric disturbances on vehicle response. In particular, atmospheric winds characterized by the magnitudes, the temporal changes, and the spatial variations of three-dimensional air motions are of major importance in the prelaunch ground environment and in the vehicle launch transit through the atmosphere. Wind loading on aerospace vehicle structures can introduce limitations in the operational capabilities of the vehicles and in the structural design and guidance control systems which, in turn, govern the functional applications of such vehicles. Thus, a thorough and detailed understanding of atmospheric winds and other interrelated meteorological factors is a necessity in establishing design criteria for aerospace vehicles and associated equipment.

Wind conditions in aerospace vehicle applications are, for operational purposes, divided into the two separate categories of ground winds and inflight winds with the distinguishing altitude being about 150 meters above the ground surface. Ground winds and other associated meteorological parameters are measured from fixed installations employing tower facilities extending to the 150-meter height. Inflight winds and other relevant inflight meteorological factors are measured by means of rawinsonde ballons, radar-tracked overpressure Jimsphere ballons, and rocketsonde atmospheric probes covering the altitude range from near surface to approximately 80 kilometers. The meteorological data acquisition system described in this report is concerned exclusively with the requirements for logging and processing ground winds and other meteorological parameters as measured from a 150-meter instrumented tower.

A well equipped meteorological tower facility [1] was constructed in 1965 on Merritt Island, Kennedy Space Center, Florida, in proximity to the Apollo/Saturn Launch Complex 39 to provide improved ground wind data and other meteorological measurements. As shown in Figure 1 this facility consists of a small tower (18 meters in height), a large elevator-equipped tower (150 meters in height), and an instrumentation building. Figure 2 shows a closeup view of the 150-meter meteorological tower. A total of 37 meteorological sensors are mounted at 3 levels on the small tower and at 6 levels on the large tower. Mounting booms are used to extend the sensors away from the tower structures, and the purpose of the small tower is to support the lower level sensors at a distance well away from air disturbances produced by the large tower structure.

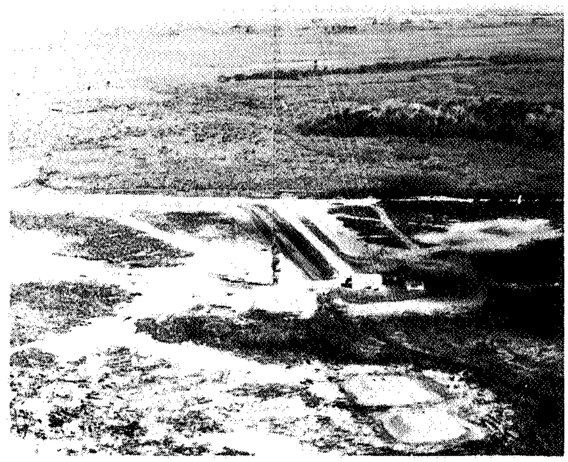

Figure 1. Overall view of 150-meter meteorological tower.

Wind and temperature profile data from this facility have contributed significantly to space vehicle wind loading design and launch ground wind criteria, especially for the Apollo/Saturn and Space Shuttle vehicle systems. This facility has also been used for extensive routine climatological data collection in other NASA atmospheric research studies which have yielded high confidence seasonal records of coastal meteorological variables at Kennedy Space Center and improved statistical design factors describing the winds, temperature, humidity, precipitation, atmospheric pressure, and solar radiation at this location. At the present level of activity, use of this tower could beneficially approach a continuous around-the-clock

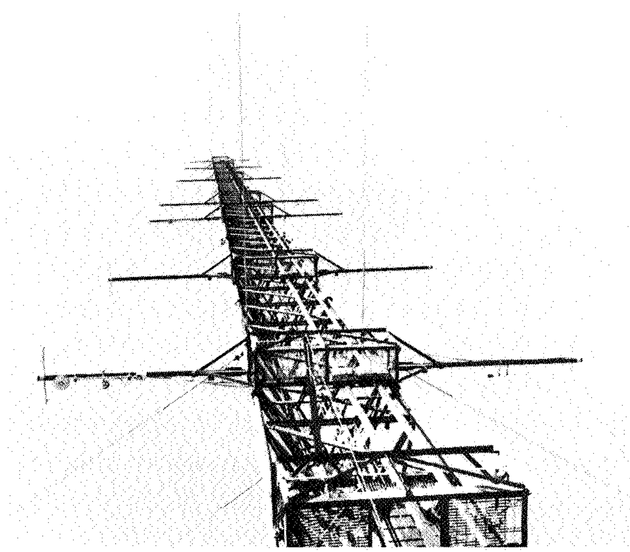

Figure 2. Closeup view of 150-meter meteorological tower.

operation for certain atmospheric studies, and it is for this purpose as well as for purposes of real-time data processing and distribution that the Automatic Data Acquisition System (ADAS) requirements were established.

Prior to incorporation of the ADAS, records of lower atmospheric profiles of temperature, winds, and humidity were obtained in analog strip chart form and manually converted to computer compatible information by rather extensive manual translation processes. Specialized short time duration atmospheric studies were also performed using higher resolution data recorded in analog form on magnetic tape. While these analysis procedures were adequate to provide accurate interpretation and analysis of the major meteorological factors necessary for lower atmospheric environmental space vehicle design, the excessively long delays in manual analog-to-digital data conversion and the high cost of processing the large volume of chart records were clearly detrimental to the progress of these efforts. Therefore, with the addition of other instruments on the tower to measure solar radiation, atmospheric pressure, and precipitation together with the need to process a larger and more frequently sampled sequence of the meteorological parameters, it became necessary to supplant the existing procedures with direct digital records and onsite climatological data processing.

Conversion of the 150-meter tower facility to automatic data acquisition entailed changing some of the meteorological sensors such as barometric pressure and humidity from mechanical readout to electrical readout as well as standardizing all of the sensor output signals for compatibility with analog-to-digital conversion and digital data recording. The meteorological parameters presented in Table 1 were measured and recorded. The particular sensor instruments and operating specifications for the sensors currently installed on the two towers will be discussed in greater detail later.

The ADAS is designed to sample the output signals from all of the meteorological sensors at a rate of 10 samples per second, corresponding to a total of 370 sensor readings per second. These data are then processed in two selectable operating modes:

1. Wind Profile Mode — Horizontal wind speed and direction, vertical wind speed, and air temperature readings at 10 samples per second, including the necessary data calibration signals, are digitally recorded as raw data on magnetic tapes for fast response wind and temperature profiles; and/or

2. Climatological Mode — Every tenth sample per second of meteorological data from each sensor is selected and averaged over each successive 10-minute time interval to yield the 10-minute means, standard deviations, maxima, and minima describing the prevailing climatological conditions. Six

TABLE 1. NUMBER AND LOCATION OF METEOROLOGICAL PARAMETERS MEASURED

Meteorological Parameter	Number of Sensors	Sensor Locations and Heights	
		Small Tower (meters)	Large Tower (meters)
Horizontal Wind Speed	9	3, 10, 18	18, 30, 60, 90, 120, 150
Horizontal Wind Direction	9	3, 10, 18	18, 30, 60, 90, 120, 150
Vertical Wind Speed	4	10	18, 60, 150
Ambient Air Temperature	1	3	-
Differential Air Temperature	6	18	30, 60, 90, 120, 150
Dew Point Temperature	3	3	60, 150
Atmospheric Pressure	1	1.5	-
Solar Radiation	1	1.5	-
Precipitation	1	1.5	-
Relative Humidity	2	1.5	120

10-minute computational sequences are performed each hour, and the final results are scaled to the desired engineering units and digitally recorded on magnetic tape and listed on the system teleprinter. The system is also capable of distributing these data to other locations by teletype.

The general design and operating details of the ADAS and samples of typical meteorological observations and processed results are described in the remaining sections of this report. Engineering design details and system operating instructions are presented in Reference 2.

TECHNICAL APPROACH – AN EFFECTIVE SOLUTION

The ADAS developed for the 150-meter ground winds tower facility at Kennedy Space Center performs the dual functions of digital data logging and real-time meteorological computation using signals from up to 45 sensors. Currently, the tower facility employs 37 active meteorological sensors and can be expanded up to 45 sensors, if required. The technical specifications and expansion capability are presented in Table 2.

The system rapidly multiplexes each sensor output signal at a rate of 10 times per second into an analog-to-digital converter and, from an accumulation of these real-time sample values, derives the mean values, standard deviations, vertical gradients, and maximum and minimum values of the various meteorological parameters. The digitally processed results are then recorded on computer-compatible magnetic tape and are also listed on teletype printout. The 10 samples per second digital data corresponding to the raw wind profiles as measured by all wind sensors on the tower can also be simultaneously stored on a separate magnetic tape record for subsequent detailed analysis.

The computational operating mode provides a 10-minute climatological average of meteorological conditions as monitored at the tower and is designed for continuous, 24 hour per day operation (climatological data updated every 10 minutes). The separate wind profile operating mode provides high resolution time-coincident sensor readings suitable for detailed study of ground winds including their gradients and statistical fluctuation characteristics.

The Meteorological Sensors

Table 3 summarizes the measured meteorological parameters, the associated sensor instruments, the instrument ranges and sensitivities,

TABLE 2. AUTOMATIC DATA ACQUISITION SYSTEM TECHNICAL SPECIFICATIONS AND EXPANSION CAPABILITY

System Function	Component and Manufacturer	Specifications	Present Utilization	Spare Capacity As Implemented	Expansion Capability With Additions
System Control and Computational Processor	Supernova General Purpose Computer — Data General, Inc.	• Instruction Format — 16-bit Word • Arithmetic Logic — Fixed-Point Hardware, Multiply and Divide • Cycle Time — 0.8 μsec • Memory Capacity — 4K Magnetic Core • Hardware Interrupts — 16 Available for Interface • Direct Memory Access Channels — 16 Available for Interface • Direct Memory Access Rate — 357 100 words/sec	— — — Approximately 4K 4 Interfaced 2 Interfaced Maximum Rate Used in Bursts	— — — None 2 None —	— — — 8K ~~16K~~ without Expansion Chassis 32K with Expansion Chassis — 14 Channels with Expansion Chassis 1.25M words/sec with High Speed Data Channel
Event Counter	Event Counter and Interface — SwRI/Data General	• Count Channels: 16 Event Count Functions — Seven 2-Input Multiplexed Seven 1-Input Direct Two Unused • Count Rate: 357 100 counts/sec Total	Six 2-Input Counters Five 1-Input Counters — Approximately 40 000 counts/sec Total	One 2-Input Counter Two 1-Input Counters — —	2 Additional One- or Two-Input Counters — — —
Multiplexed Analog-to-Digital Converter	Multiplexer/Converter — Raytheon Model MADC 10-08 Interface — SwRI/Data General	• Analog Input: Number of Channels — 48 Maximum Throughput Rate — 33 000 samples/sec Input Voltage Range — 0 to 5 volts • Analog-to-Digital Conversion: Type — Successive Approximation Resolution — 10 bits Accuracy — 0.1 percent Output Code - Binary	40 33 000 samples/sec 0 to 5 volts — — — —	8 — — — — — —	256 with Additional Switches — — — — — —
Signal Conditioners	Comparator Amplifier — SwRI	• Event Channel Buffer Amplifier: Number of Channels — 17 Input Level — >2.4 volts Output Level — TTL Logic	15 — —	2 — —	1 by Adding Components to Existing Circuit Card
	Linear Amplifier — SwRI	• Analog Channel Buffer Amplifier: Number of Channels — 17 Input Levels — 0 to 1 volt Output Level — 0 to 5 volts	15 — —	2 — —	1 by Adding Components to Existing Circuit Card
	One-Shot Multivibrator and Comparator Amplifier — SwRI	• Precipitation Channel Buffer Amplifier: Number of Channels — 1 Input Level — >2.4 volts Output Level — TTL Logic (100-msec Pulse)	1 — —	None — —	—
Signal Translators	Climet 020-1 (2 ea.)	• Horizontal Wind Speed and Direction: Number of Channels — 18	16	2	None
	Climet 060 — Model 015-5	• Differential Temperature: Number of Channels — 8	6	2	None
	Climet 060 — Model 70736	• All other Sensors: Number of Channels — 20	12	None	8 by Adding Circuit Cards
Magnetic Tape Recorders	Kennedy Model 1610 — M/S Digital Tape Recorder Interface — SwRI	• Number of Recorders — 2 • Recorder Type — Incremental 7-Track 556 bits/inch Fast Gap • Writing Rate — 750 steps/sec	Used for Profile and Climatological Tape Records.	None	None
Teleprinter	Teletype Model ASR-35 Interface — SwRI	• Speed: 10 characters/second • Punched Paper Tape Read/Write	Used for Climatological Printout.	None	Remote Terminals may be added by means of dc Lines or Acoustical Couplers.
Time Code Reader/Generator	Gulton Model DST-740 Interface — SwRI	• IRIG-B Time Code • Numeric Output Indicator for Hour and Minute • Parallel BCD Output for Hour and Milliseconds	Used as Decoder for IRIG-B Range Time Code.	—	—
System Display Panel	SwRI	• Measurement Select Switches: Two 10-Position BCD Code Thumbwheels with One 4-bit Code for Sensor Type and One 4-bit Code for Tower Height • Numeric Output Indicator: Light-Emitting Diodes — 3 1/2 digits Display Range — ± 1999 • Fault and Alarm Indicators: Lamps Audible Alarm	Display Selected Measurement Values in Correct Engineering Units Updated Nine Times Per Second. Used to Indicate and Display Timing Error and ac Power Failure.	One 4-bit Code Decoded to 1-of-16 Output. Indicate Failures of the Two Magnetic Tape Recorders. Indicate that Selected Sensor is off-line. Two Spare Indicator Lamp Drivers.	Units of Measurement can be Displayed by Additional Decoder. Software Programs can be added to Utilize Magnetic Tape Recorder Fault Indicators, Inoperative Sensors, or Spare Channel Conditions.

TABLE 3. SUMMARY OF METEOROLOGICAL INSTRUMENTATION AND DATA PROCESSING AT THE KENNEDY SPACE CENTER 150-METER GROUND WINDS TOWER FACILITY

Meteorological Parameter	Sensor Type Manufacturer and Model	Number and Height of Sensors: Small Tower No.	Small Tower Height (m)	Large Tower No.	Large Tower Height (m)	Measurement Range	Sensor Sensitivity	Sensor Output After Signal Conditioning	Computations Performed and Recorded: 10-minute Mean	10-minute Standard Deviation	Maximum: 10-minute	Maximum: Hour	Maximum: Day	10-minute Minimum	Raw Data: 10 samples/second
Horizontal Wind Speed	Climet Corp. Model 011-1 Cup Anemometer	1 1 1	3 10 18	2 2 2 2 2 2	18 30 60 90 120 150	0.23 to 49 m/sec	v(m/sec) = 0.0142 f (Hz) + 0.23	Variable Frequency Pulse-Train Translated to Digital PRF Measured over 0.10-sec Time Period (000 to 350 decimal equivalent digital word.)	X	X	X	X	X	X	X
Horizontal Wind Direction	Climet Corp. Model 012-1 Vane	1 1 1	3 10 18	2 2 2 2 2 2	18 30 60 90 120 150	0 to 360 deg	0.013 Vdc/ deg	Linear Analog Voltage (0 to 5 Vdc)	X	X	X	X	X	X	X
Vertical Wind Speed	R. M. Young Co. Model 27100 Gill Propeller Anemometer	1	10	1 1 1	18 60 150	± 0.15 m/sec to ± 22.4 m/sec	3.149 rps/ m/sec	Linear Analog Voltage (0 to 5 Vdc) 2.5 Vdc-0.0 m/sec	X	X	X	X	X	X	X
Ambient Temperature	Climet Corp. Model 015-5 Thermistor Sensor	1	3	-	-	- 5°C to + 45°C	832 ohms/ °C	Linear Analog Voltage (0 to 5 Vdc)	X	-	-			-	X
Differential Temperature	Climet Corp. Model 015-5 Thermistor Sensor	1	18	1 1 1 1 1	30 60 90 120 150	± 11.1°C about ambient	832 ohms/ °C	Linear Analog Voltage (0 to 5 Vdc)	Instantaneous Samples taken at Midpoint of 10-minute Period						X
Dewpoint Temperatures	Climet Corp. Model 015-12	1	3	1 1	60 90	- 17.8°C to + 37.8°C	+ 0/056°C	Linear Analog Voltage (0 to 5 Vdc)	Instantaneous Samples taken at Midpoint of 10-minute Period						-
Atmospheric Pressure	Climet Corp. Model 0502-1 Pressure Transducer	1	1.5	-	-	914.22 mb to 1066.59 mb (27 to 31.5 inches Hg)	± 1.5 mb	Linear Analog Voltage (0 to 5 Vdc)	X	-	-			-	-
Humidity	Climet Corp. Model 016-51 Relative Humidity Sensor	1	1.5	1	120	0 to 100% RH	8 mV/ percent RH	Linear Analog Voltage (0 to 5 Vdc)	X	-	-			-	-
Solar Radiation	Eppley Model 50	1	1.5	-	-	Maximum Sun and Sky Radiation	7.5 mV/ gm-cal/cm²/ min	Linear Analog Voltage (0 to 5 Vdc)	X	-	-			-	-
Precipitation	Belfort Inst. Co. Model 5-405 Tipping Bucket Rain Gage	1	1.5	-	-	Cumulative 0.01-inch increments	0.01 inch	Event Contact Closure/Increment	X	-	-			-	-

the sensor heights, and the various computations performed on the sensor output signals.

The Data Acquisition System

The ADAS is designed to accomplish two distinct tasks:

1. Wind Profiles — Sample and record up to 37 wind and temperature related parameters at a rate of 10 samples per second, continuously, for periods of several hours at a time; and

2. Climatological Computations — Compute and record up to 157 climatological values during successive 10-minute averaging periods, repetitively, on a continuous basis. The computed values consist of the means, maxima, minima, standard deviations, instantaneous samples, totals, and times of occurrence of certain events. The sampling rate of 10 samples per second is reduced to a rate of 1 sample per second for these computations.

Data records for each of these operating modes are written on separate 7-track, 0.5-inch magnetic tapes in binary format. A teletype, used as the basic input-output control console, also prints out the climatological records every 10 minutes on an 8.5 by 11-inch page. The computed values of the climatological record are scaled to the appropriate engineering units prior to recording and printout. Selection and control of the various operating modes and types of output records are controlled at the discretion of the operator.

Time synchronization is maintained by use of the Kennedy Space Center IRIG-B range timing signal. Synchronization occurs automatically when range timing reaches the beginning of each even 10-minute period within any hour.

The functional design of the ADAS is illustrated in the simplified block diagram shown in Figure 3. As shown in the block diagram, 10 different meteorological parameters are measured with multiple sensors used for horizontal wind speed, horizontal wind direction, vertical wind speed, dewpoint temperature, relative humidity, and vertical differential temperature. A total of 37 meteorological sensors are presently in active service. A special wind bank direction/sensor ~~band~~ selector, previously developed by the Aerospace Environment Division, Aero-Astrodynamics Laboratory, Marshall Space Flight Center, is used to indicate which one of two separate banks of six boom-mounted horizontal wind sensors on opposite sides of the tower are in the

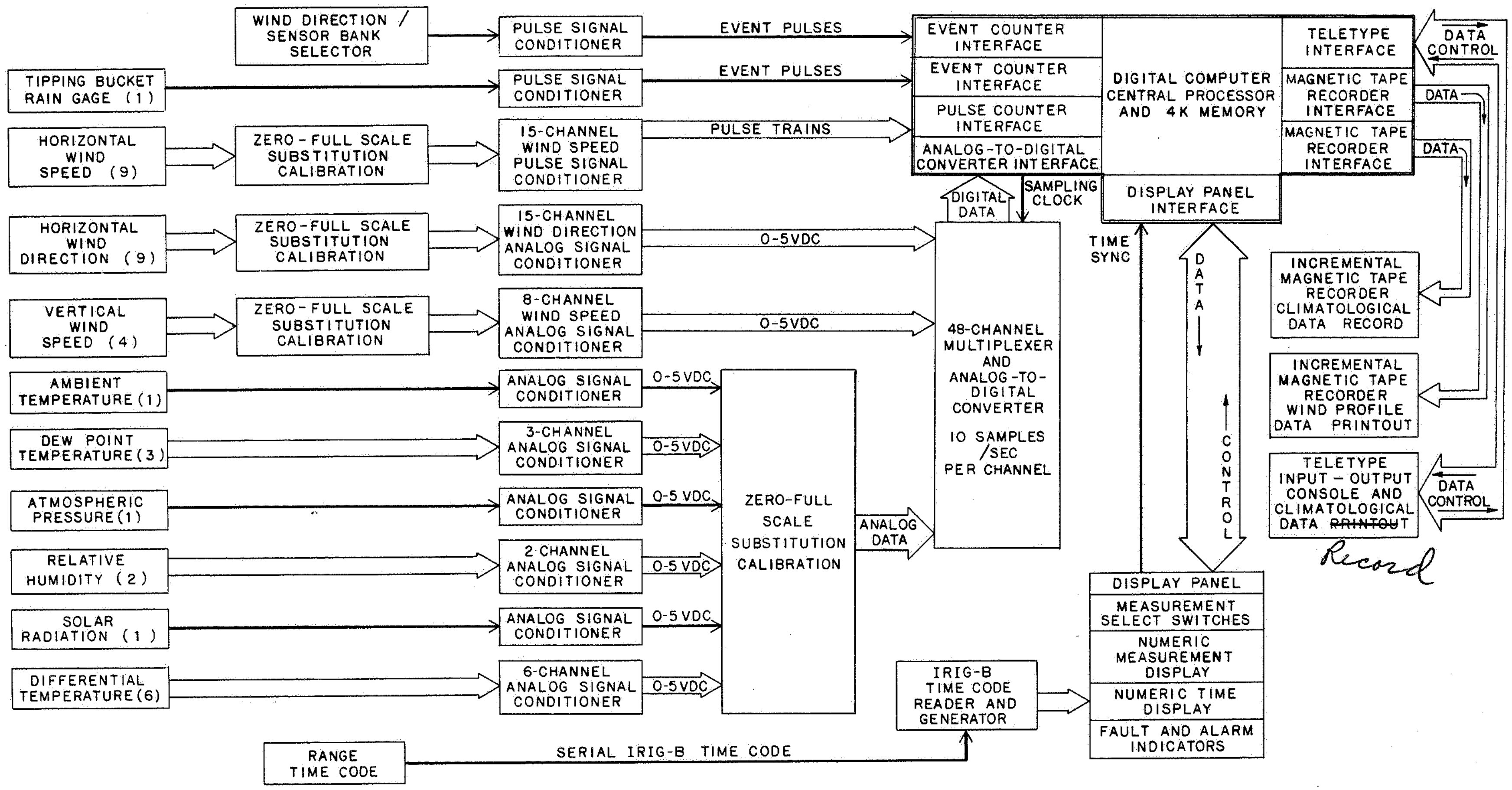

Figure 3. Simplified block diagram of the Automatic Data Acquisition System.

upwind direction. Signals from this unit are then utilized by the system computer to govern the choice of horizontal wind sensor data to be used in the various data logging and computational processes.

Signal conditioners translate the analog output signals from each sensor to standard pulses and/or standard voltage ranges compatible with the analog-to-digital conversion process. Pulse signals generated by the horizontal wind speed sensors and the tipping bucket rain gage are converted to computer-compatible logic pulses and coupled directly into the computer for cumulative counting and sampling by the central processor control program. Similarly, pulses from the wind direction/sensor bank selector and the range timing source are interfaced directly into the computer as digital control and synchronization functions.

Standardized voltages from the remaining sensors are sampled at a rate of 10 samples per second and converted to digital form by means of a computer-controlled multiplexer and analog-to-digital converter. Special interface circuits are used to interconnect the resulting digital data signals into the computer for scaling, processing, and logging.

System calibration is accomplished by substituting pulse trains of known frequency or analog voltages of known level into each sensor channel. Calibration signals corresponding to zero and full scale sensor output levels are used as a direct means for checking and adjusting the various signal-conditioning amplifiers for routine climatological mode operation. In the wind and temperature profile operating mode, the zero and full scale calibration signals are recorded on the magnetic tape records for subsequent use in interpreting the actual magnitudes (and signs where applicable) of the digitized sensor output signals. Scaling of the monitored meteorological parameters into the desired engineering units is accomplished in the computer by use of appropriate conversion factors derived from the sensor sensitivities and the calibration input voltages.

Under computer program control, the acquired data is fed to two separate incremental magnetic tape recorders for climatological and wind profile data recording. A teletype input-output console is used to enter the various data annotations identifying the magnetic tape records and to select the desired computer operation and data acquisition modes, including hard-copy printout of the climatological data.

The system display panel serves as a convenient means for monitoring the real-time output of any one of the meteorological sensor channels on a selectable basis. Thus, by means of channel selector switches, the digitized and properly scaled outputs of any sensor channel can be observed in real time on a numeric display at anytime during system operation. This feature is especially useful in performing the various system calibration tests and in periodically checking the functional status of the meteorological sensors. System fault and alarm indicators in the form of lamps and an audible tone generator are also provided on the display panel to indicate the absence of range time code signal, incorrect time-of-day synchronization, ac power failure, and magnetic tape recorder status. The audible alarm operates whenever time-of-day synchronization is incorrect and whenever power failure occurs.

Time-of-day is also indicated by a numeric display on the display panel. Range timing signals (IRIG-B) from Kennedy Space Center are decoded by a time code reader/generator unit for purposes of data acquisition time synchronization and real-time display. The local time code generator is a similar IRIG time clock that can be selected for use in place of the range timing signal.

Special provisions are made to protect the ADAS including the stored control programs and processed data under conditions of ac power failure. Whenever an ac line voltage variation of sufficient magnitude to cause improper system operation is detected in the computer, the normal data acquisition program is interrupted and a special power-fail routine is called up for the purpose of halting the system operation in an orderly manner before power to the computer decays past the point of accurate operation. Presently, the system requires manual intervention to properly annotate the data records upon automatic restart; however, the system has the necessary skeletal program control features to implement this procedure automatically in the future so that such power failures can be accommodated in the absence of an operator.

Figure 4 illustrates the final ADAS hardware. The two equipment cabinets contain the complete digital data acquisition system. The analog sensor signal-conditioning translators are installed at a separate location and connected to the left-hand equipment rack by cables. Equipment panels shown in the left-hand rack are, from top to bottom: (1) two panels for cable connection terminal boards; (2) computer-interface electronic circuits; (3) display panel; (4) multiplexer and analog-to-digital converter; (5) digital computer; (6) cabinet drawer; and (7) power supplies and cabinet ventilation fan. The right-hand rack contains the two incremental magnetic tape recorders. The teletype console shown on the left is a heavy-duty unit equipped with a punched paper tape read/write unit and a hard-copy printer.

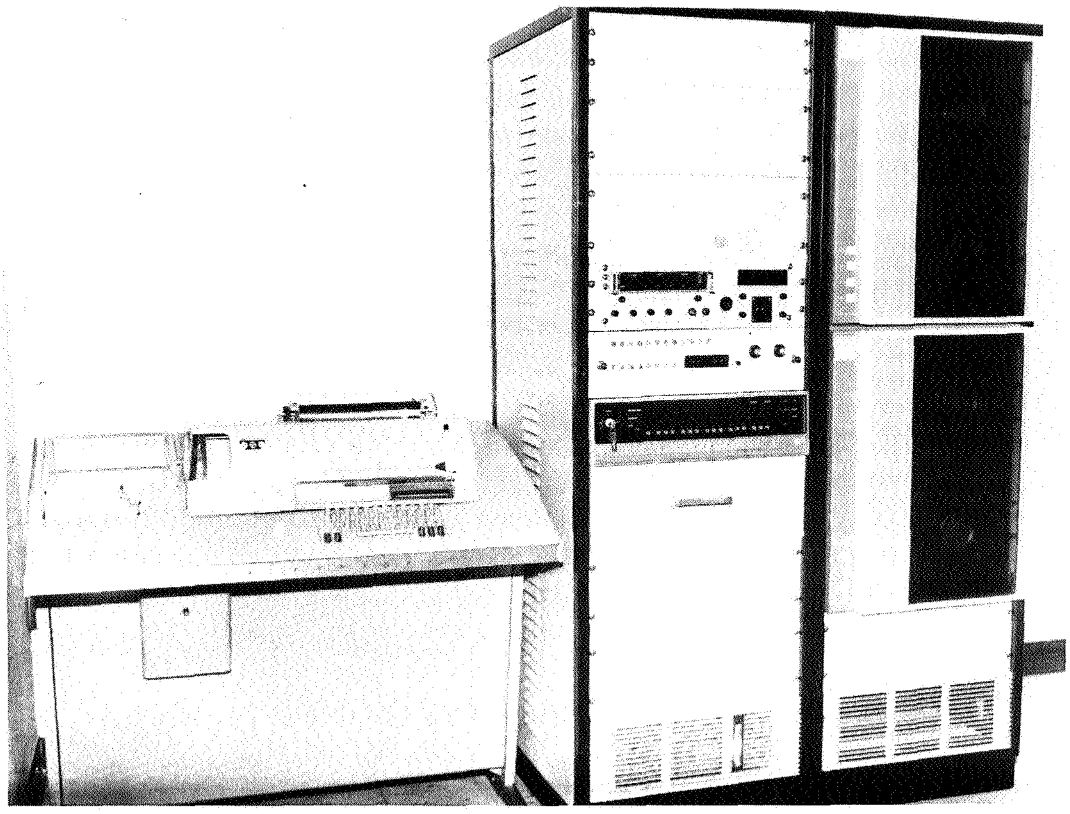

Figure 4. Automatic Data Acquisition System.

The Climatological Computations

The climatological data acquisition and processing mode derives a total of 157 meteorological values related to conditions observed during the 10-minute measurement period together with hourly and daily maximum values. The sample values used in the computations are all positive quantities since they are either cumulative pulse counts or converted from positive analog voltages. Thus, only positive integer arithmetic is necessary in the data processing routines.

Preliminary processing of the raw data is first performed to convert each channel of the 10 samples per second data to 1 sample per second information for averaging purposes. Thus, the climatological computations performed during each 10-minute period utilize 600 data points from each meteorological sensor. Also, since the horizontal wind direction signals are discontinuous functions because of the nature of the wind vane sensor construction, another preliminary processing routine is utilized to remove the ambiguities in these data prior to the normal computations.

Computer algorithms are provided to compute the mean value of the meteorological parameters and the standard deviations of horizontal wind speed, horizontal wind direction, and vertical wind speed. Instantaneous readings of vertical differential temperatures and dewpoint temperature are taken at the midpoint of each 10-minute averaging period. Additionally, for each 10-minute averaging period the maximum and minimum instantaneous valuês of horizontal wind speed, horizontal wind direction, and vertical wind speed are acquired. The successive maxima and minima exceeding previous values on an hourly basis and on a 24-hour daily basis are stored in the magnetic tape records and printed out as part of the climatological results. The times of occurrence of the horizontal wind speed hourly and daily maxima are also recorded.

To conserve computer memory, the means and standard deviations are derived using running sums and running sums of squares of the sampled data accumulated over each 10-minute averaging period. Analytically stated, the computational functions for any sampled meteorological variable, X , are

$$\text{Mean Value} = \frac{1}{N} \sum_{n=1}^{N} X_n \quad ,$$

$$\text{Mean Square Value} = \frac{1}{N} \sum_{n=1}^{N} (X_n)^2 \quad ,$$

and

$$\text{Standard Deviation} = \sqrt{(\text{Mean Square Value}) - (\text{Mean Value})^2} \quad ,$$

where

$X_n = X(t_0 + n\tau) =$ sampled values of X,

$n = 1, 2, \ldots, N,$

$$N = 600,$$

and

$$\tau = 1 \text{ second.}$$

Scaling of the data is performed at the end of the computational sequences to save computer time. The positive unscaled quantities representing the meteorological samples vary from 0 to 1024. Scaling is carried out in accordance with the linear relationship,

$$\text{Scaled Result} = \frac{aX}{1024} - b \quad ,$$

where

$$a = \text{full scale value},$$

$$X = \text{value to be scaled},$$

and

$$b = \text{zero offset.}$$

The Operating Scheme

The ADAS operates in a programmed manner under operator control. Various operator actions are required to initially start the system, to introduce the necessary data identification and header information for the data output records, to select the system operating modes and associated output records to be produced, and to halt the system. Other normal operator functions are to perform the various meteorological sensor tests and system calibration procedures, to maintain the proper magnetic tape and printout supplies, to make periodic checks on the status of the meteorological sensors, and, in case of range timing or ac power failures, perform the necessary actions to resynchronize or restart the system.

Figure 5 is a simplified flow chart which diagrammatically illustrates the sequence of events that occur in the ADAS. This self-explanatory chart summarizes the various functional operating sequences and operator control points in the overall system.

The Hardware and Installation

Figures 6 through 13 illustrate the ADAS, emphasizing the equipment's modular construction, the ease of access, the interwiring, and the final installation.

FIELD TESTS AND TYPICAL DATA – THE RESULTS

Installation of the ADAS and acceptance tests were performed at Kennedy Space Center in the spring of 1971. Installation documentation, refinement of system software functions, and orientation training of operator personnel were completed and the system was placed in service in the summer. Routine operation in the climatological mode has resulted in a large quantity of fully processed meteorological information describing the coastal weather conditions at Kennedy Space Center since that time. Similarly, wind profiles have been acquired for subsequent detailed analysis of the statistical wind loading effects on space vehicle booster rockets and other real-time ground wind studies. The system, through wire-line connections with other operations at Kennedy Space Center, has also provided critical up-to-the-minute weather information for rocket launch control and related activities.

Climatological Data

A typical climatological data report is illustrated in Table 4. This printout summarizes the average conditions during the 10-minute time period beginning at 30 minutes past the sixth hour of the day on March 3, 1972, as reproduced from data stored on magnetic tape. A similar data format is used with the teletype printout; however, to conserve space in the teletype output, code abbreviations are used to identify the parameters being measured. Header information in the first two lines of this printout identifies the record. The meteorological information in the listing is in tabular form where the data in each column correspond to the various sensor readings from the different tower elevations in meters. The first column of data represents surface

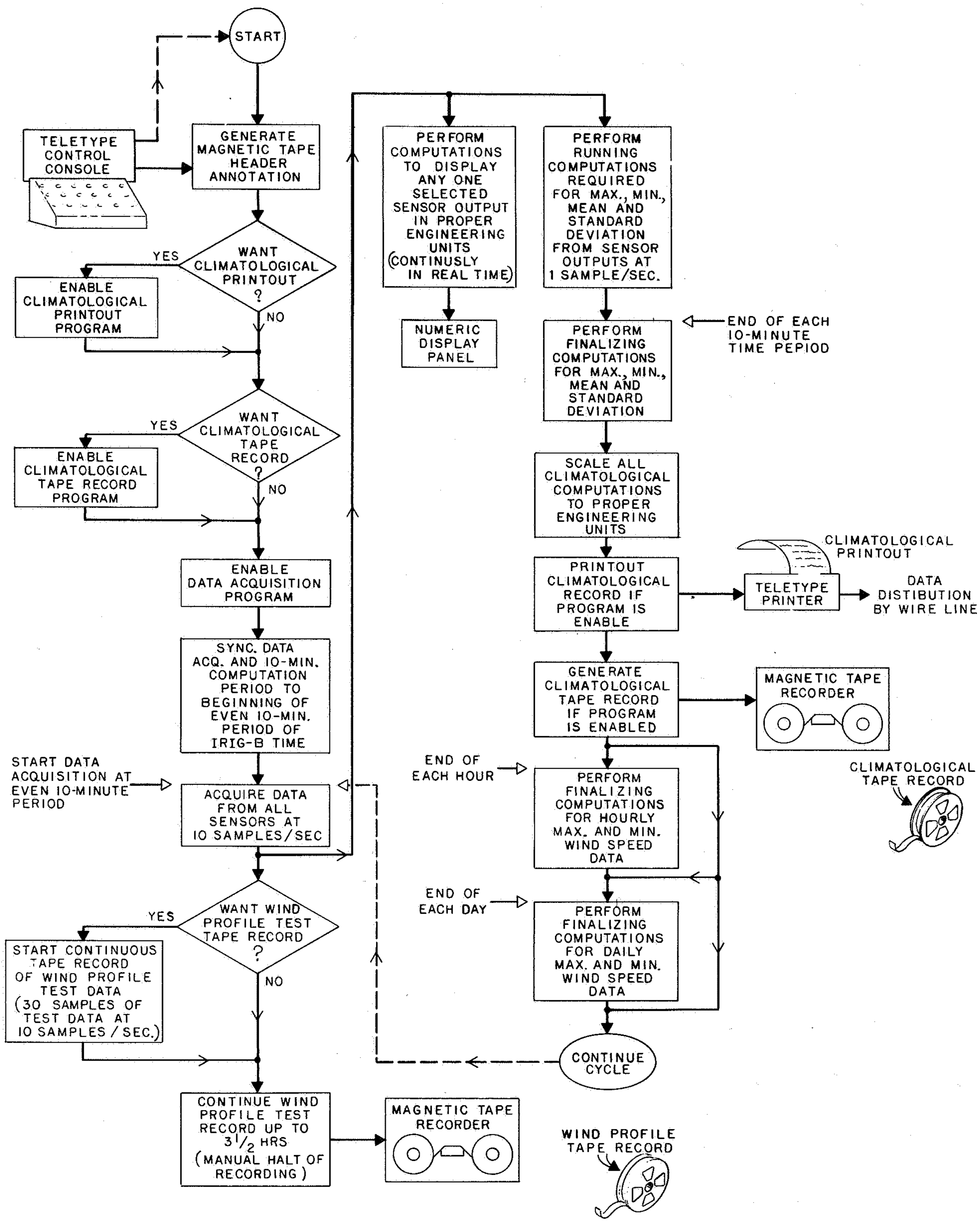

Figure 5. Simplified flow diagram of the Automatic Data Acquisition System.

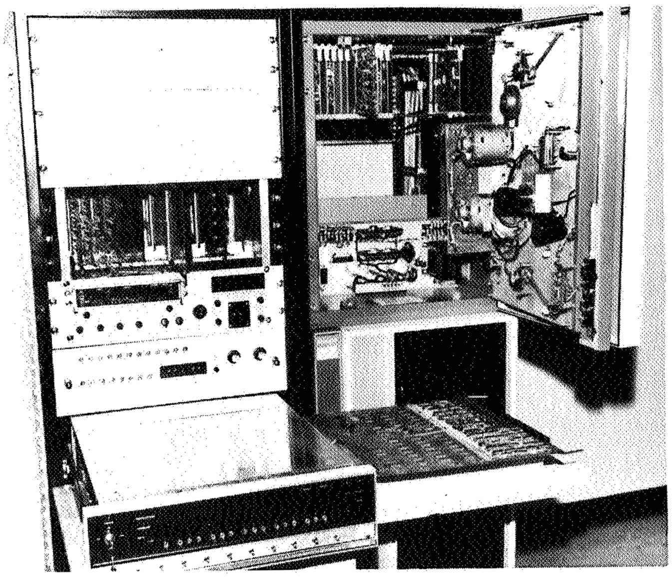

Figure 6. Modular construction view of the Automatic Data Acquisition System.

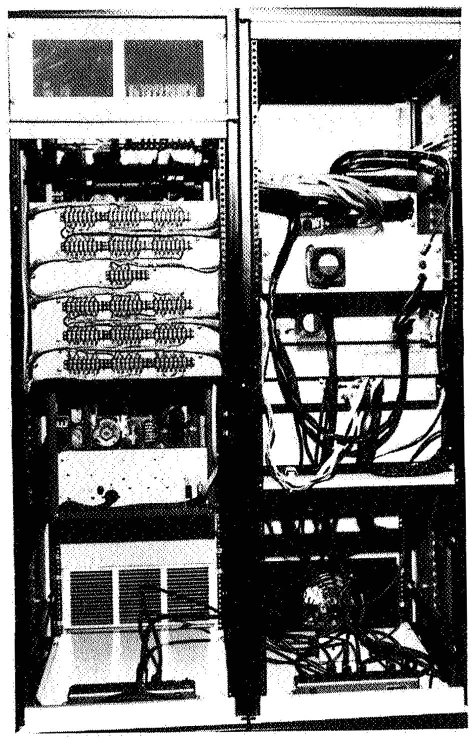

Figure 7. Back view of the Automatic Data Acquisition System showing interconnections.

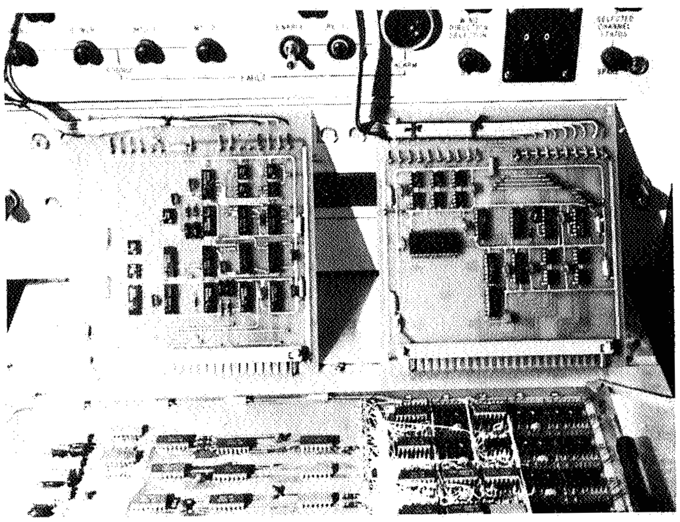

Figure 8. Digital interface cards for select switches and fault and alarm indicators.

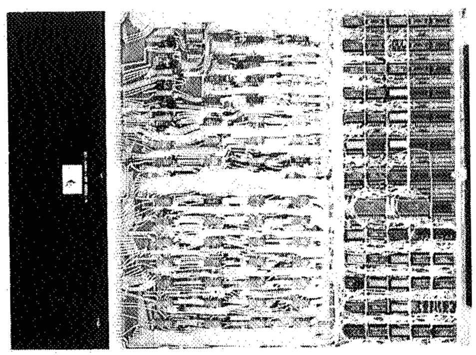

Figure 9. Event and digital input/output circuits on a Data General general purpose interface board.

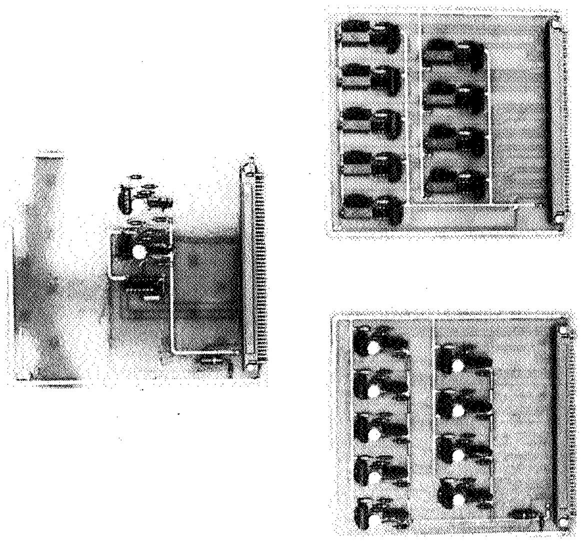

Figure 10. Event and pulse signal conditioners.

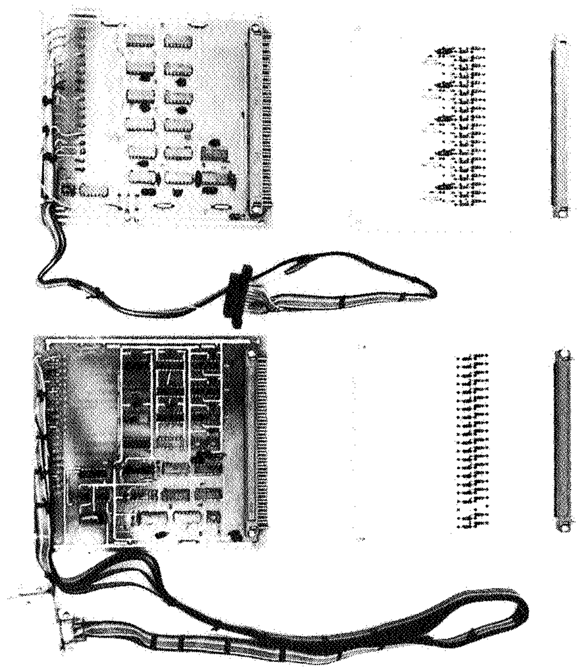

Figure 11. Digital interface cards for time code read/generate and measured value display indicator.

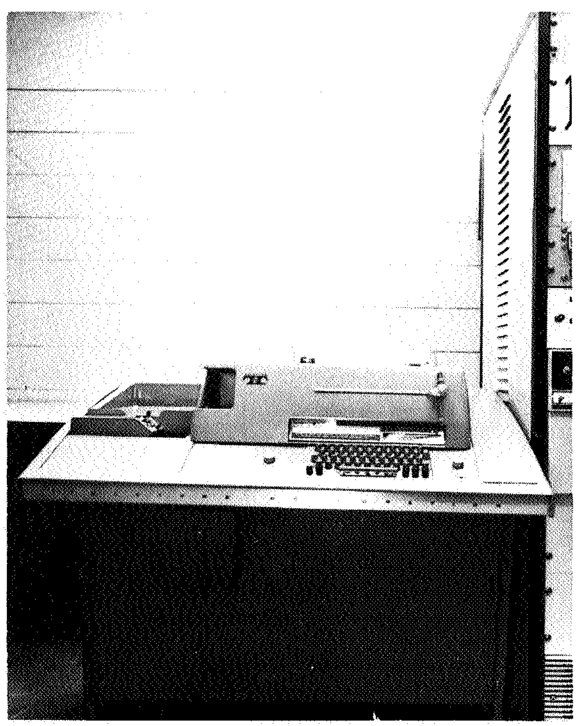

Figure 12. Automatic Data Acquisition System teletype console.

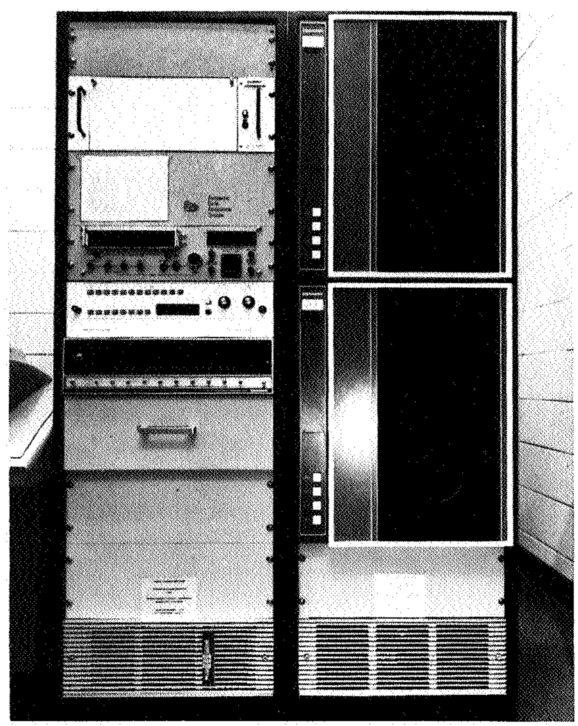

Figure 13. Automatic Data Acquisition System final installation.

TABLE 4. TYPICAL CLIMATOLOGICAL DATA REPORT — 0630 HOURS ZULU, MARCH 3, 1972

HOUR= 6.0 MINUTES =30.0
DAY= 3.0 MONTH= 3.0 YEAR=72.0

INSTRUMENT LEVEL(METERS)	1.5	3	10	18S	18L	30	60	90	120	150
TOWER SIDE(1 IS NE, 2 IS SW, 3 IS CHANGE OVER)	1.0									
MEAN ATMOSPHERIC PRESSURE(MB)	1012.5									
MEAN RELATIVE HUMIDITY(PERCENT)	84.5								88.9	
MEAN SOLAR RADIATION(CAL/CM2/MIN)	0.0									
MEAN PRECIPITATION(INCHES)	0.2									
MEAN AMBIENT TEMPERATURE(C)		18.6								
DEWPOINT TEMPERATURE(C)		14.8					14.3		16.6	
DELTA TEMPERATURE(C)				0.8		1.7	0.1	0.3	0.5	0.3
MAXIMUM HORIZONTAL WIND SPEED(M/S)		2.3	2.7	3.9	3.9	4.8	5.8	6.1	5.4	6.2
MEAN HORIZONTAL WIND SPEED(M/S)		1.1	1.7	2.5	2.5	3.4	4.2	4.7	4.1	4.8
MINIMUM HORIZONTAL WIND SPEED(M/S)		0.6	0.9	1.7	1.4	2.5	3.4	3.9	2.8	3.9
STANDARD DEVIATION OF HOR. W/S		0.2	0.5	0.7	0.7	0.2	0.8	0.9	0.8	0.5
W/D ASSOC. WITH MAXIMUM W/S		317.0	328.0	343.0	339.0	330.0	333.0	356.0	345.0	358.0
MEAN WIND DIRECTION		237.0	317.0	342.0	332.0	342.0	334.0	358.0	345.0	339.0
W/D ASSOC. WITH MINIMUM W/S		307.0	306.0	342.0	322.0	331.0	339.0	5.0	348.0	352.0
STD. DEV. OF WIND DIRECTION		151.0	11.0	7.0	7.0	7.0	5.0	5.0	4.0	10.0
MAX. VERTICAL WIND SPEED			0.1		0.3		0.6			0.4
MEAN VERTICAL WIND SPEED			-0.2		-0.2		-0.2			-0.1
MIN. VERTICAL WIND SPEED			-0.5		-0.7		-0.6			-0.6
STD. DEV. OF MEAN W/S			0.2		0.2		0.3			0.2
HOURLY MAX. HOR. W/S		4.7	5.5	5.8	7.0	6.2	7.6	8.9	8.0	8.4
DAILY MAX. HOR. W/S		8.0	9.6	10.0	10.1	11.0	13.1	13.7	13.4	13.4
W/D ASSOC. WITH HOURLY MAX. W/S		316.0	313.0	336.0	356.0	345.0	327.0	3.0	350.0	351.0
W/D ASSOC. WITH DAILY MAX. W/S		329.0	288.0	333.0	331.0	329.0	269.0	283.0	277.0	274.0
TIME OF OCCURRENCE OF HOURLY MAX.		614	605	610	604	611	611	604	604	610
TIME OF OCCURRENCE OF DAILY MAX.		549	503	543	543	543	502	502	502	502

(1.5 meter) values of pressure, relative humidity, solar radiation, and precipitation. Also listed in this column is a number that indicates which bank of wind sensors was used to collect the wind data and whether a change occurred from one bank to the other during the 10-minute observation period. This latter information is obtained from a special two-potentiometer direction sensor mounted on a short mast at the top of the small tower.

The data presented in Table 4 are generally self-explanatory. It is only necessary to clarify that the header identification time represents the beginning of the 10-minute observation and is given in universal time (GMT). The times of maximum horizontal wind occurrence given in the last two lines of the listing are for the current hour and day stated in the header identification for the 24-hour period beginning at 0000Z. The vertical wind data are signed information, where positive indications represent upward air movement and negative indications represent downward air movement. The maximum and minimum values of vertical winds are those which occurred during the specified 10-minute observation period.

The results of several atmospheric studies which have utilized data collected from the 150-meter ground winds tower facility at Kennedy Space Center have been reported elsewhere [3-6]. A partial list of users of these data, in addition to NASA, include the U. S. Air Force, the National Weather Service, the National Bureau of Standards, various colleges and universities, and private industry.

Wind Profile Data

When operating in the wind profile mode, the ADAS acquires only wind and temperature information in high resolution magnetic tape form. These data records are then used in subsequent interpretive turbulence studies having practical aerospace applications in vehicle wind loading, ground winds turbulence spectra, and other related vehicle design and operational wind criteria. The wind profile records are also used in various other ground winds studies including analysis and statistical characterization of winds associated with severe storms. With the activation of the ADAS, temperature measurements have been added to the high resolution data records as a valuable adjunct to the atmospheric profile studies. However, because of previous activities predominantly involving wind studies, the records are still referred to as "wind profile data".

Wind profile data are collected and recorded in real time wherein 23 wind-related data points and 6 temperature-related data points are each recorded in digital form at a rate of 10 samples per second. Prior to real-time recording, the data tape is annotated and identified in free format by teletype keyboard or previously punched paper tape. Also, since the data points are recorded in raw form, the necessary calibration signals and scaling constants are included as preliminary information prior to the wind profile recording.

A 5-second sequence of wind profile data is illustrated in Tables 5 and 6. These data were selected from a 1.5-hour continuous wind profile run obtained to check out the ADAS system operation. Table 5 presents the horizontal wind speed (WS) and vertical wind speed (VWS) data as measured at three small tower levels (S3, S10, and S18) and at the six large tower levels (L18, L30, L60, L90, L120, and L150). Table 6 presents the horizontal

TABLE 5. A 5-SECOND SEQUENCE OF WIND PROFILE DATA REPRODUCED FROM A 1.5-HOUR MAGNETIC TAPE RECORD — HORIZONTAL AND VERTICAL WIND SPEED

KSC METEOROLOGICAL TOWER
AUTOMATIC DATA ACQUISITION SYSTEM 1.5 H O U R W I N D P R O F I L E

HR	MIN	SEC	WSS3	WSS10	WSS16	WSL10	WSL30	WSL60	WSL90	WSL120	WSL150	VWSS10	VWSL18	VWSL60	VWSL150
13	16	40.1	2.9	3.7	4.4	5.0	5.1	5.3	3.2	3.9	4.4	-0.01	-0.48	0.29	-1.31
13	16	40.2	3.0	3.7	4.6	4.7	5.1	5.4	3.2	3.7	4.3	-0.05	-0.48	0.34	-1.27
13	16	40.3	3.0	3.7	4.4	4.6	5.0	5.3	3.3	3.7	4.4	-0.05	-0.48	0.31	-1.22
13	16	40.4	3.0	3.9	4.3	4.5	5.1	5.4	3.4	3.7	4.3	-0.05	-0.43	0.34	-1.31
13	16	40.5	3.0	4.0	4.3	4.5	5.1	5.3	3.3	3.7	4.3	-0.05	-0.48	0.31	-1.31
13	16	40.6	3.0	4.0	4.3	4.6	5.0	5.3	3.4	3.7	4.1	-0.08	-0.45	0.31	-1.34
13	16	40.7	3.0	4.0	4.1	4.7	4.6	5.1	3.6	3.6	4.1	-0.05	-0.48	0.36	-1.41
13	16	40.8	2.9	4.0	4.0	4.5	4.5	5.1	3.9	3.4	4.1	-0.05	-0.50	0.36	-1.41
13	16	40.9	2.9	4.0	4.0	4.4	4.6	5.0	3.7	3.7	4.3	-0.01	-0.50	0.34	-1.36
13	16	41.0	3.0	3.9	4.1	4.3	4.5	5.1	3.6	3.7	4.1	0.01	-0.48	0.34	-1.31
13	16	41.1	3.0	4.1	4.0	4.1	4.8	5.1	3.7	3.6	4.3	-0.05	-0.52	0.31	-1.22
13	16	41.2	3.0	4.0	4.3	4.3	4.7	5.0	3.7	3.7	4.3	0.03	-0.57	0.41	-1.15
13	16	41.3	3.0	4.1	4.1	4.3	4.7	5.1	3.7	3.7	4.3	0.03	-0.52	0.36	-1.13
13	16	41.4	3.0	4.1	4.0	4.3	4.7	5.1	3.6	3.9	4.1	-0.01	-0.55	0.36	-1.08
13	16	41.5	3.0	4.3	4.0	4.1	4.8	5.1	3.6	3.9	4.1	-0.01	-0.52	0.36	-1.06
13	16	41.6	2.9	4.1	4.0	4.4	4.6	5.1	3.7	3.9	4.3	-0.03	-0.43	0.36	-0.99
13	16	41.7	3.0	4.1	3.9	4.4	4.7	5.3	3.6	4.0	4.1	-0.01	-0.38	0.41	-1.04
13	16	41.8	2.9	4.1	3.7	4.4	4.7	5.1	3.4	4.0	4.1	-0.03	-0.38	0.41	-1.13
13	16	41.9	2.9	4.1	3.9	4.6	4.7	5.1	3.4	4.0	4.4	-0.03	-0.41	0.36	-1.13
13	16	42.0	2.7	4.0	3.7	4.7	4.6	5.1	3.7	3.9	4.0	-0.01	-0.43	0.36	-1.13
13	16	42.1	2.7	4.0	3.7	4.6	4.6	5.1	3.6	3.7	4.1	-0.01	-0.45	0.41	-1.17
13	16	42.2	2.7	4.0	3.7	4.4	4.7	5.0	3.6	3.7	4.0	-0.05	-0.38	0.41	-1.17
13	16	42.3	2.9	4.1	3.7	4.7	4.8	5.1	3.9	3.9	4.1	-0.05	-0.29	0.36	-1.15
13	16	42.4	2.9	4.0	3.7	4.7	4.8	5.0	4.0	3.9	4.1	-0.05	-0.24	0.36	-1.08
13	16	42.5	2.7	3.9	3.9	4.4	4.7	5.1	4.0	3.9	4.1	-0.05	-0.15	0.36	-1.08
13	16	42.6	2.7	3.9	3.7	4.4	4.6	5.0	3.9	3.9	4.3	-0.05	-0.05	0.36	-0.94
13	16	42.7	2.7	3.9	3.6	4.1	4.4	5.0	3.9	4.0	4.1	-0.05	-0.10	0.38	-0.94
13	16	42.8	2.6	3.7	3.7	4.3	4.3	4.8	4.0	3.9	4.1	-0.10	-0.22	0.36	-0.99
13	16	42.9	2.6	3.7	3.9	4.6	4.4	5.0	4.0	3.9	4.3	-0.15	-0.22	0.41	-1.04
13	16	43.0	2.7	3.7	4.0	4.6	4.1	4.8	4.0	4.0	4.1	-0.10	-0.15	0.36	-1.04
13	16	43.1	2.7	3.9	3.9	4.7	4.1	4.8	4.1	3.9	4.3	-0.20	-0.15	0.45	-0.94
13	16	43.2	2.7	3.9	4.1	4.7	4.1	5.0	3.9	4.1	4.1	-0.27	-0.15	0.41	-0.94
13	16	43.3	2.7	4.1	4.1	4.7	4.1	5.0	3.9	4.0	4.4	-0.38	-0.20	0.43	-0.94
13	16	43.4	2.7	4.0	4.3	4.6	4.0	5.0	3.9	4.1	4.3	-0.52	-0.29	0.41	-0.94
13	16	43.5	2.7	4.1	4.4	4.6	4.0	5.1	4.1	4.0	4.4	-0.43	-0.38	0.41	-0.90
13	16	43.6	2.5	4.0	4.4	4.6	4.1	5.1	3.7	3.9	4.4	-0.38	-0.45	0.38	-0.90
13	16	43.7	2.6	4.0	4.4	4.7	4.1	5.0	3.9	4.1	4.3	-0.34	-0.48	0.43	-0.85
13	16	43.8	2.5	3.9	4.4	4.6	4.1	5.0	3.9	4.0	4.3	-0.43	-0.50	0.43	-0.94
13	16	43.9	2.2	3.9	4.3	4.7	4.4	5.0	4.0	4.1	4.1	-0.45	-0.52	0.45	-0.94
13	16	44.0	2.3	3.7	4.4	4.6	4.3	4.8	3.9	4.1	4.3	-0.38	-0.50	0.43	-0.90
13	16	44.1	2.2	3.7	4.3	4.6	4.3	5.0	4.0	4.1	4.3	-0.36	-0.57	0.41	-0.92
13	16	44.2	2.2	3.7	4.4	4.6	4.3	4.7	4.0	4.0	4.1	-0.36	-0.57	0.41	-0.94
13	16	44.3	2.2	3.4	4.4	4.4	4.4	4.6	4.1	4.1	4.3	-0.38	-0.59	0.36	-0.99
13	16	44.4	2.0	3.4	4.4	4.1	4.3	4.7	4.1	4.0	4.0	-0.43	-0.57	0.41	-0.94
13	16	44.5	2.3	3.6	4.4	4.3	4.3	4.6	4.1	4.1	4.1	-0.36	-0.59	0.41	-0.94
13	16	44.6	2.3	3.4	4.4	4.3	4.4	4.8	4.4	4.0	3.9	-0.29	-0.62	0.36	-0.90
13	16	44.7	2.2	3.3	4.4	4.0	4.4	5.1	4.1	4.1	4.1	-0.29	-0.59	0.36	-0.85
13	16	44.8	1.9	3.4	4.5	3.9	4.4	5.1	4.0	4.1	3.9	-0.24	-0.52	0.36	-0.80
13	16	44.9	2.0	3.4	4.5	3.9	4.3	5.0	4.4	4.1	4.0	-0.20	-0.48	0.31	-0.80
13	16	45.0	2.0	3.5	4.4	3.9	4.4	5.1	4.1	4.3	3.9	-0.20	-0.43	0.36	-0.76

wind direction (HWD) as measured at all nine tower levels and the ground-level ambient temperature (AT) and differential temperatures (DT) relative to the ambient as measured at one level on the small tower and five levels on the large tower. As may be noted in the left hand columns of these tables, the time increment between samples is 0.1 second.

CONCLUSIONS — THE PRESENT AND THE FUTURE

The ADAS recently developed for NASA has overcome a major limitation in collecting and processing data associated with a variety of atmospheric dynamic studies. In particular, the excessive time lag between data collection and processed results has been reduced from several months to a matter of

TABLE 6. A 5-SECOND SEQUENCE OF WIND PROFILE DATA REPRODUCED FROM A 1.5-HOUR MAGNETIC TAPE RECORD — HORIZONTAL WIND DIRECTION AND TEMPERATURE

KSC METEOROLOGICAL TOWER
AUTOMATIC DATA ACQUISITION SYSTEM — 1,5 H O U R W I N D P R O F I L E

HR	MIN	SEC	HWDS3	HWDS10	HWDS18	HWDL18	HWDL30	HWDL60	HWDL90	HWDL120	HWDL150	DTS10	DTL30	DTL60	DTL90	DTL120	DTL150	ATL3
13	16	40.1	12[illegible],0	162.6	122,8	117,2	116,5	101,0	121,1	127,0	121,4	0,0	-1,3	-1,6	-1,6	-2,4	-2,9	29,2
13	16	40.2	111,9	158.7	120,7	118,6	116,5	100,3	122,1	129,5	123,5	-0,0	-1,3	-1,7	-1,7	-2,4	-3,0	29,2
13	16	40.3	105,9	155.9	120,7	118,2	116,8	101,7	123,2	129,9	122,5	0,0	-1,4	-1,7	-1,6	-2,4	-2,9	29,1
13	16	40.4	104,5	155.9	121,4	117,9	117,5	102,8	127,7	127,7	122,8	0,0	-1,4	-1,7	-1,7	-2,4	-3,0	29,1
13	16	40.5	105,2	155.9	121,4	117,5	118,9	102,8	133,4	129,1	122,1	0,0	-1,3	-1,7	-1,6	-2,4	-2,9	29,2
13	16	40.6	106,7	156.6	121,4	118,6	120,0	102,4	134,1	128,5	122,1	0,0	-1,4	-1,6	-1,6	-2,4	-2,9	29,2
13	16	40.7	131,3	157.3	122,8	117,9	119,3	102,4	129,9	128,4	121,9	-0,0	-1,3	-1,7	-1,7	-2,4	-3,1	29,3
13	16	40.8	124,9	157.3	123,5	117,9	117,5	101,3	124,9	128,5	122,1	-0,0	-1,3	-1,7	-1,6	-2,4	-2,9	29,2
13	16	40.9	131,3	157.7	124,2	116,1	116,5	101,7	121,4	127,7	122,8	0,0	-1,3	-1,7	-1,7	-2,4	-2,9	29,2
13	16	41.0	132,0	160.8	123,5	116,9	117,2	101,3	120,0	127,0	124,2	0,0	-1,3	-1,7	-1,5	-2,6	-3,0	29,1
13	16	41.1	126,4	159.4	122,8	117,5	117,9	101,7	120,4	128,5	128,4	-0,0	-1,3	-1,7	-1,6	-2,5	-3,1	29,2
13	16	41.2	126,7	159.4	117.9	117,9	116,6	102,1	120,7	129,9	129,5	0,0	-1,3	-1,7	-1,7	-2,4	-2,9	29,2
13	16	41.3	117,2	160.1	115,1	118,2	119,3	102,1	122,1	129,9	127,0	-0,0	-1,3	-1,7	-1,7	-2,4	-3,1	29,3
13	16	41.4	113,7	157.7	117,9	115.1	121,4	102,8	124,2	130,5	124,2	-0,0	-1,3	-1,7	-1,6	-2,4	-2,9	29,2
13	16	41.5	113,[illegible]	154.1	114,9	113,0	123,2	103,5	125,6	128,4	122,8	0,0	-1,4	-1,7	-1,7	-2,4	-2,9	29,2
13	16	41.6	113,7	157.7	119,3	110,9	122,8	103,1	127,7	127,0	121,4	0,0	-1,3	-1,7	-1,6	-2,5	-3,2	29,1
13	16	41.7	113,0	155.9	119,3	110,9	121,4	103,8	127,0	124,9	122,5	-0,0	-1,3	-1,7	-1,7	-2,4	-3,0	29,2
13	16	41.8	112,9	155.7	123,5	109,4	121,4	103,8	124,9	126,3	122,8	0,0	-1,3	-1,7	-1,6	-2,5	-3,1	29,1
13	16	41.9	11[illegible],9	155.5	129,9	108,7	120,0	103,8	122,1	127,0	122,8	0,0	-1,3	-1,7	-1,5	-2,4	-2,9	29,2
13	16	42.0	109,4	155.7	137,6	110,9	119,3	103,8	120,7	125,5	124,9	0,0	-1,3	-1,7	-1,6	-2,4	-2,9	29,1
13	16	42.1	[illegible]	153.6	143,2	113,0	119,3	103,8	118,6	127,0	124,9	0,0	-1,3	-1,6	-1,6	-2,4	-2,9	29,1
13	16	42.2	[illegible]	151.5	145,3	114,0	119,3	103,8	116,1	129,1	127,7	0,0	-1,3	-1,7	-1,6	-2,4	-2,9	29,1
13	16	42.3	[illegible]	146.2	144,6	114,4	119,3	102,4	114,4	129,1	126,3	-0,0	-1,2	-1,7	-1,5	-2,4	-3,0	29,2
13	16	42.4	107,0	144,6	142,5	113,7	118,6	104,2	113,7	131,3	126,3	0,0	-1,2	-1,7	-1,6	-2,5	-2,9	29,1
13	16	42.5	1[illegible],3	143.9	139,0	112,3	118,9	104,5	113,0	132,0	127,0	0,0	-1,3	-1,5	-1,5	-2,4	-2,9	29,1
13	16	42.6	105,9	143.6	136,2	111,9	117,9	104,9	112,3	132,0	125,3	-0,0	-1,2	-1,7	-1,5	-2,4	-2,9	29,1
13	16	42.7	105,9	143.2	132,7	112.3	117,5	104,9	109,4	128,4	125,5	-0,0	-1,2	-1,7	-1,7	-2,4	-3,1	29,2
13	16	42.8	107,3	143.6	129.1	114,0	116,1	103,5	104,5	127,7	126,3	-0,0	-1,2	-1,7	-1,5	-2,4	-2,3	29,1
13	16	42.9	11[illegible],9	141.6	126,3	113,7	115,1	103,8	98,9	127,4	124,9	-0,0	-1,3	-1,7	-1,5	-2,4	-2,9	29,1
13	16	43.0	11[illegible],5	141.1	125,3	113,0	114,4	103,5	96,1	129,9	127,0	-0,0	-1,2	-1,7	-1,7	-2,4	-3,0	29,2
13	16	43.1	117,9	144.5	126,4	110.1	114,7	103,5	94,7	134,6	125,5	-0,0	-1,2	-1,7	-1,5	-2,4	-3,0	29,2
13	16	43.2	11[illegible]	145.0	130,6	109,4	114,7	102,4	98,9	136,9	125,5	0,0	-1,3	-1,7	-1,6	-2,4	-2,8	29,2
13	16	43.3	11[illegible],1	140.4	130,6	108,7	114,0	101,7	104,5	136,2	123,5	0,0	-1,3	-1,6	-1,6	-2,4	-2,9	29,1
13	16	43.4	105,9	137.2	129,1	109,1	115,1	101,7	108,7	137,6	124,9	0,0	-1,2	-1,7	-1,6	-2,4	-2,9	29,1
13	16	43.5	99,6	134.6	127,7	109,1	115,2	100,3	108,7	134,8	125,6	-0,0	-1,2	-1,7	-1,6	-2,4	-3,0	29,2
13	16	43.6	95,3	135,5	127,0	108.7	116,5	98,5	109,4	135,5	128,4	-0,0	-1,2	-1,7	-1,5	-2,4	-3,0	29,2
13	16	43.7	94,7	137.9	126,4	106,4	116.1	96,6	109,1	134,4	132,3	0,0	-1,3	-1,7	-1,6	-2,4	-2,9	29,1
13	16	43.8	93,3	139.7	126,4	106,7	116,3	98,2	108,7	136,2	131,3	0,0	-1,2	-1,7	-1,6	-2,4	-3,0	29,1
13	16	43.9	94,7	139.4	129,9	106.4	116,5	99,9	108,7	135,5	130,9	0,0	-1,2	-1,7	-1,6	-2,4	-2,9	29,1
13	16	44.0	94,[illegible]	138.3	129,1	109,4	115,8	101.7	108,7	136,2	127,7	0,0	-1,3	-1,7	-1,6	-2,4	-2,8	29,1
13	16	44.1	94,0	135.5	126,6	110,1	115,1	101,3	110,5	135,1	123,5	0,0	-1,3	-1,7	-1,6	-2,4	-2,9	29,1
13	16	44.2	94,7	131.3	127,7	111,9	115,1	100,3	113,0	138,3	123,7	0,0	-1,2	-1,7	-1,6	-2,4	-3,0	29,2
13	16	44.3	95,4	133.7	127,7	112,3	115,1	101,0	113,0	135,3	117,9	-0,0	-1,2	-1,7	-1,7	-2,4	-3,1	29,2
13	16	44.4	9[illegible],1	135.5	126,3	113,0	115,5	99,9	114,4	134,3	119,3	0,0	-1,2	-1,7	-1,5	-2,4	-3,2	29,2
13	16	44.5	9[illegible],1	134.8	126,3	113,0	117,9	100,3	115,1	132,0	119,3	0,0	-1,3	-1,7	-1,5	-2,4	-2,9	29,1
13	16	44.6	94,7	132.7	129,1	112,3	118,6	101,7	113,3	131,3	120,7	-0,0	-1,2	-1,7	-1,7	-2,4	-3,0	29,1
13	16	44.7	[illegible],4	130.6	131,6	113,0	117,9	102,8	111,9	129,5	121,4	0,0	-1,2	-1,7	-1,7	-2,4	-3,0	29,1
13	16	44.8	9[illegible],2	129.1	130,2	112,3	116,5	101,7	112,3	129,1	123,5	0,0	-1,3	-1,7	-1,6	-2,4	-2,9	29,2
13	16	44.9	9[illegible],9	134.8	129,5	113,0	115,8	101,3	111,6	129,9	122,8	0,0	-1,3	-1,7	-1,5	-2,4	-2,9	29,1
13	16	45.0	[illegible]	142.9	128,4	113,7	115,1	101,0	112,6	131,6	123,7	-0,0	-1,2	-1,7	-1,6	-2,4	-2,9	29,1

hours or days. Moreover, the use of additional sensors for supplemental meteorological measurements and the facility to transfer and distribute the observed and processed climatological data by teletype in real time has far exceeded the previous capabilities for utilizing the ground winds tower facility at Kennedy Space Center. The advantages and expediencies provided by the ability to automatically record and process the desired data have resulted in major reductions in data processing time and manpower and have removed the unavoidable approximations and human errors associated with the manual handling of such large amounts of data. Thus, the ADAS and related expansions of the meteorological tower facility represent an especially cost effective improvement in many associated NASA technical applications.

The system design approach has provided specific solution to the current data collection requirements at the tower. However, in addition to these capabilities, the nature of the system concept and the hardware implementation offer the inherent potentials for incorporating updating changes in functional operation, variations in computational data processing, expansion of capability, and adaptation to other similar automatic data acquisition applications. Indeed, in the course of providing the most appropriate and convenient system to NASA on delivery and checkout, several technical features of the hardware system as well as the software control programs were modified and improved during installation at the tower site. Therefore, the system is, on the one hand, a customized system capable of serving a dedicated data acquisition purpose and, on the other hand, is also a flexible system capable of being adapted to the many changing requirements in the types of measurements, data processing functions, and data output records and formats.

Since completing the installation and checkout last year, the system has been functionally operational for at least 60 percent of the time. To date the system has been operated primarily in the climatological mode, although wind profile records have been acquired on several occasions and can be obtained at any time on operator command. Data acquisition requirements have not demanded unattended 24 hour per day continuous operating service so far; however, system checkout tests have proven the reliability and readiness of the installation. According to the present operating schedule, the ADAS functions unattended for approximately 16.5 hours out of each 24 hour day on Saturday, Sunday, Monday, and Tuesday and is unattended for 10 hours on Wednesday, Thursday, and Friday.

The general success of this data acquisition system emphasizes the growing application of small general-purpose digital computers to problems of high volume data recording, real-time measurements, and signal processing and of serving redundant data handling functions that are costly and inefficient when manually performed. In this particular meteorological application the significant expansion in data volume, the time coherence of certain critical meteorological measurements, and the rapid availability of the processed results have opened new and more relevant areas of research in atmospheric dynamics and related applications.

Thus, this equipment provides essential atmospheric data for research and operations of NASA's overall aerospace vehicle program.

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APPROVAL

AN AUTOMATIC DATA ACQUISITION SYSTEM FOR THE 150-METER GROUND WINDS TOWER FACILITY, KENNEDY SPACE CENTER

By

Wilson B. Tarver, Jr., Thomas E. Owen, and Dennis W. Camp

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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ERRATA

NASA TM X-64708

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September 1972

Title page, Block 7: Wilson B. Traver, Jr. should read Wilson B. Tarver, Jr.

Page v: Figure 8 reads "Digital interface cards for select switches and fault alarm indicators". It should read "Digital interface cards for select switches and fault and alarm indicators."

Page 6, Table 2, Column 6: First item reads "6K without Expansion Chassis." It should read "8K without Expansion Chassis."

Page 8, 4th line from bottom of page reads "direction/ sensor band selector ..." It should read "direction/ sensor bank selector..."

Page 9, Figure 3, right side, 2nd block from bottom: Last item in block reads "Data Printout." It should read "Data Record."